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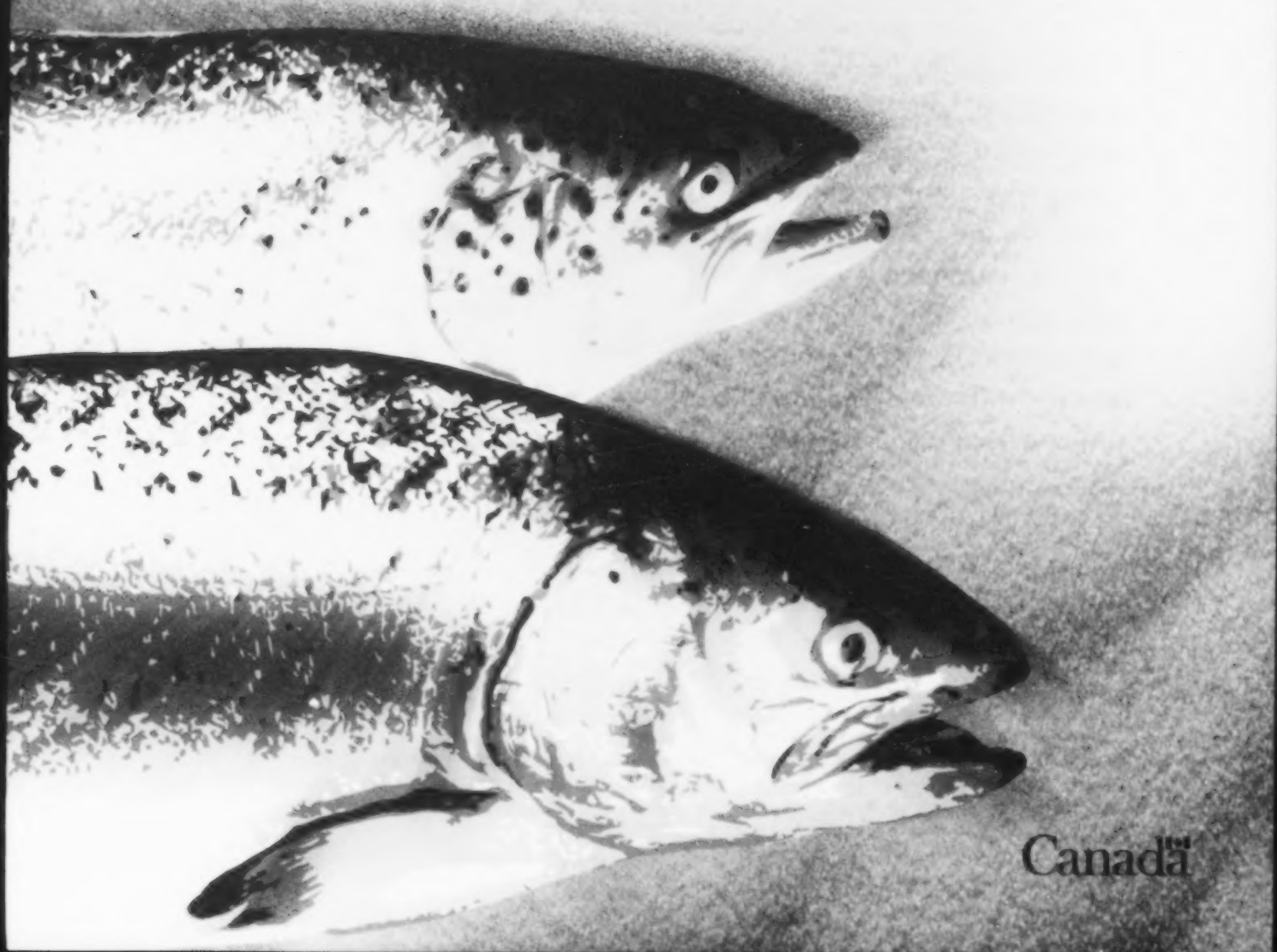
UNDERWATER world

PACIFIC SALMON



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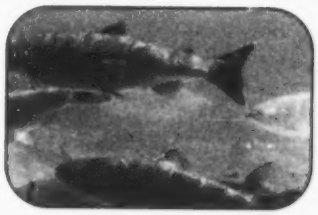

Pacific Salmon

Habits and History of Salmon

There are seven species of North American Pacific salmon: chinook, chum, coho, cutthroat, pink, steelhead and sockeye. Although each species has a unique appearance and different habits, they share many characteristics. They are *anadromous* — meaning their eggs are laid and hatch in freshwater, and their young spend at least some of their early lives in freshwater before swimming to the sea to grow and mature. Their ability to find their way home again when it is time to reproduce is one of the most remarkable things about salmon. In fact, salmon have been known to travel thousands of kilometres in the ocean, as well as battle strong river currents and waterfalls to reach their hatching place. Pacific salmon, with the exception of cutthroat and steelhead, spawn only once and die within days of digging their nests or "redds" in the gravel and mating. Their bodies float down rivers and decompose, filling the water with nutrients for other species of animals and plants. Live and dead salmon are also important food for birds like eagles and gulls, and mammals such as bears and otters. In this way, salmon contribute to the health of freshwater ecosystems.

Salmon lay their eggs in nests or "redds" that the females dig in the gravels of streams or in some cases lakeshores. The gravel must be free of silt and well oxygenated. Young salmon require cold, clean, well-oxygenated water. They are very sensitive to any activities that reduce the quality of their freshwater habitat. Industrial activities like forestry and farming, and other human activities like building roads and cities, can damage or destroy freshwater salmon habitats if they are not carried out in an environmentally friendly manner.

Salmon have existed for millions of years. They provided food for First Nations living along the coast and interior of British Columbia for thousands of years. Since the late 1800s, salmon have supported a vibrant commercial fishing industry, vital to the establishment and well

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being of many coastal communities. Sport fishing for salmon is also a popular recreational activity for local citizens as well as visitors.

In addition to having different spawning habits, each species has a unique appearance and life history.

Chinook *(Oncorhynchus tshawytscha)* are the largest of the Pacific salmon, weighing from 3 to 50 kilograms, when they return to spawn. Chinook are also called spring salmon because some populations or "stocks" return to their river in the spring. This early appearance means that this species was often the first salmon of the year for many First Nations in British Columbia. Other stocks return during the summer and fall. In large rivers like the Fraser, chinook salmon of different stocks are returning from March to November, with peaks in early July, mid-August and early October.

There can be several different types of chinook salmon with different combinations of run-timing (spring/summer or summer/fall) and early life history (immediate ocean entry, 90-day entry or entry after one year) in even small coastal rivers. Once in the ocean the young fish spend several weeks to months in the estuary or near the shore. Generally, spring/summer migrating stream-type chinook range further into the ocean than do the early migrating ocean-type fish, which have a more coastal distribution. The fry in headwater populations or in colder northern rivers spend a year in freshwater after emergence.

Chinook, especially larger and older fish are piscivorous, meaning that they eat fish. Because of their large size and presence in coastal waters, chinook are one of the favoured prey of killer whales and recreational and commercial fishers. Chinook are typically fished in "hook and line" fisheries where they chase and bite lures or baited hooks being trolled through the water. Chinook are an unusual Pacific salmon species because the flesh of adults can range in colour from white through pink to deep red. Colour in other species is normally the same in all populations ranging from white in chum to deep red in sockeye.

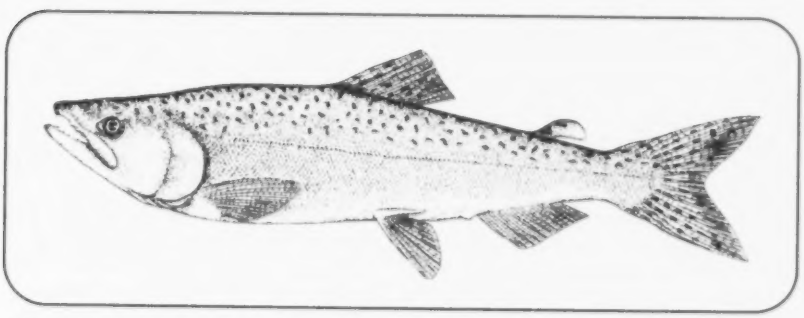

Figure 1. Chinook salmon (Oncorhynchus tshawytscha)

Chinook salmon have varied and complex life histories. The populations of small coastal rivers usually return in the fall while the populations using the headwaters of the tributaries of large rivers like the Fraser and Skeena usually return early in the spring. The young of fall run chinook populations typically swim to the ocean either immediately or after several months subsequent to hatching and emerging from the gravel. The young of spring and summer runs usually spend a year in freshwater.

Pink salmon *(Oncorhynchus gorbuscha)* return in prodigious numbers to many rivers in British Columbia. They are the smallest, the youngest at maturity and the most abundant of the Pacific salmon. Spawning pinks generally weigh from 1.5 to 3 kilograms and are always two years of age. Another name for this species is the "humpy". As they mature, male pinks develop large humped-backs, which make them appear larger during territorial battles on spawning grounds. Immediately after they emerge from the gravel in the spring, the young pink fry enter the ocean and after a few days to several months in the estuary and nearshore zone, they move out into the open ocean in large schools. There, pink salmon feed on the small and nearly invisible animals called zooplankton and especially krill, which gives their flesh the bright pink colour for which they are named. In many rivers pink salmon are abundant every year, but in other rivers they appear only every second year. In the Fraser River pinks are

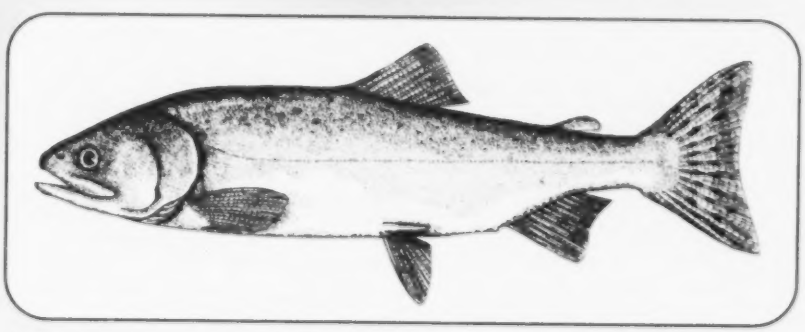

Figure 2. Pink salmon (Oncorhynchus gorbuscha)

abundant in the odd years (2003, 2005, etc.) but are rare in the even years. Pink salmon used to be caught exclusively in gill net and seine net fisheries, but are now also taken by hook and line fisheries. Odd-year pink salmon were accidentally introduced into the Great Lakes in 1955 and have since spread throughout the five lakes. An even-year run has also developed and was shown to have been the progeny of three-year old odd-year spawners.

Sockeye *(Oncorhynchus nerka)* were the first species to be caught commercially. They were considered suitable for canning because of their deep red colour and high oil content. Sockeye salmon are slightly larger than pink salmon and generally mature at four or five years of age. Unlike the young of other species that live in flowing water, young sockeye salmon are found in lakes where they feed on zooplankton. However, some sockeye populations behave very much like pink and chum salmon and their young enter the ocean soon after hatching. Scientists think that these "river-type" sockeye are the ancestral form that populated all of the lakes of British Columbia after the end of the last glaciation 14,000 years ago. The Kokanee salmon, which are found in many lakes in British Columbia, are actually land-locked sockeye salmon. In some cases they are found in lakes that have no anadromous sockeye, while in other lakes both types are present. Because the Pacific Ocean offers more types of food to young sockeye, they grow larger and faster than kokanee. Although sockeye and kokanee can mate, the offspring of such pairings are poorly adapted for life either in the lake or the ocean and do not appear to survive.

One of the most remarkable features of sockeye is a phenomenon called "cyclic dominance". In many of the lakes of the Fraser River in particular, sockeye are abundant in one of every four years. Sockeye can mature at ages between two and six years old but in most systems, one age group (usually four-year-old fish) dominates, meaning that most of the offspring produced in any one "brood-year" return to spawn four years later. In many populations, all of the brood-years are about equally abundant, but in many of the populations within the Fraser River there are many more fish in one of the brood-years, the "dominant cycle", than in any of the other three. This cyclic dominance leads to spectacular returns to the Adams River every four years (2002 is in the dominant cycle). Although there are many ideas about why this occurs, nobody knows for sure.

Sockeye appear to be highly adapted to their natal lake. Things like the migration route that the fry must take from the spawning grounds to the lake, the timing of spawning and the time of emergence are all particular to individual lakes. This not only makes each sockeye population special, but also means that sockeye cannot be readily moved from one lake to another with any degree of success. Sockeye are mostly caught in gill and seine net fisheries along migration pathways to their spawning grounds.

Chum *(Oncorhynchus keta)* weighing from 3 to 10 kilograms are the large salmon that spawn in the lower reaches of most coastal streams and rivers in the summer and fall. Spawning chum are readily recognized by the dark horizontal stripe running down their sides, the canine-like teeth of the large males and the checkerboard or calico colouration. Chum salmon are the most widely distributed of the Pacific salmon. In North America, chum are found from Monterey California to east of the Mackenzie River on the Beaufort Sea, and may have made up 50 per cent of the total biomass of all species of Pacific salmon combined.

The species name *"keta"*, which means fish, comes from the Nanai people of Kamchatka in eastern Russia and is an indication of the importance of the species to Aboriginal people around the Pacific Rim. Like the young of pink salmon, the fry of chum salmon do not spend any time in freshwater, leaving immediately for the ocean where they spend from two to six years and range far out into the open ocean. Chum salmon are perhaps the most intensively cultivated of the Pacific salmon. Chum salmon are the poorest jumpers of the Pacific salmon world and waterfalls that do not impede any of the other species can often stop their upstream migration.

The flesh of chum salmon is relatively low in oil making them ideal for cold smoking, which together with their abundance made the species a food staple for coastal First Nations. In general, chum

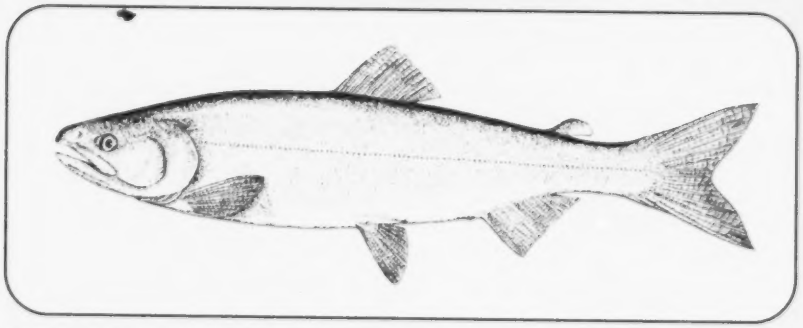

Figure 3. Sockeye salmon (Oncorhynchus nerka)

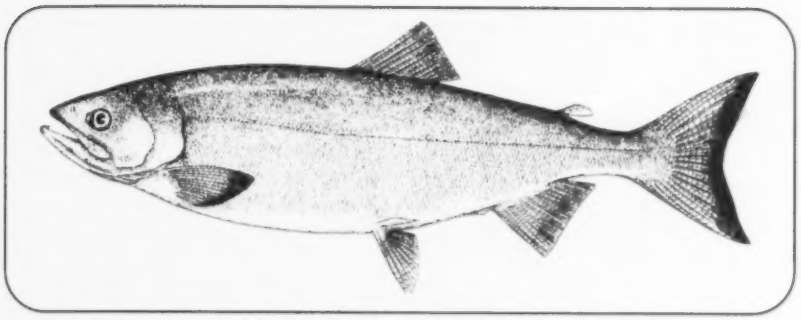

Figure 4. Chum salmon (Oncorhynchus keta)

spawn close to the ocean in small coastal streams. These stream areas are commonly highly affected by habitat damage in the watershed. Activities like logging, agriculture, road and bridge construction and municipal development introduce sediment into streams. Clearing streamsides leads to increased water temperatures. All of these effects are concentrated in the lower sections of coastal rivers and can severely affect chum (and pink) salmon. Chum salmon are typically caught in net fisheries often off river mouths but are also taken in commercial and recreational troll fisheries.

Coho *(Oncorhynchus kisutch)* can be found in most waters that drain into the Pacific Ocean, so there are more populations of coho than of any other Pacific salmon species in British Columbia. Young coho generally spend one year in freshwater although in northern populations, high proportions of juveniles spend two or even three years in freshwater before entering the ocean. Juvenile coho favour small streams, sloughs and ponds, but coho populations can also be found in lakes and large rivers. In some coastal streams, large numbers of newly emerged fry appear to move to the ocean like chum and pink. Coho juveniles are territorial while in freshwater and will vigorously defend their territories against other coho and trout. Juvenile coho can be brightly coloured with orange-red bodies and dramatic black and white edges on the anal and dorsal fins. While defending their territories, they make threatening displays by turning sideways to the intruder and spreading their fins to make themselves appear as large as possible. At the same time, the small fish can shimmy and shake in a display called the "wig-wag dance". This and other behaviour of young coho have been widely studied.

There is only so much space for territories in streams so the number of young coho is limited and there is intense competition for what space there is. Individuals that cannot find or defend a territory do not survive well. A consequence of this territoriality is that a stream tends to produce the same number of smolts year after year regardless of the number of adults that spawn in it. That average number of smolts is called the "carrying capacity" of the stream. Unlike the other salmon species, which generally migrate long distances in the open ocean, coho remain in coastal waters. Their proximity to land, their willingness to take lures and their tendency to jump and dodge makes them a favourite among sport fishers. Coho are also caught in large numbers in commercial troll fisheries. Coho were intensively harvested over the last few decades and there have been recent population crashes that prompted severe restrictions in all fisheries.

Steelhead *(Oncorhynchus mykiss)* formerly considered a trout species, is now thought by biologists to be more closely related to Pacific salmon than other trout. Like sockeye, the steelhead has a common freshwater form known as rainbow trout, of which there are six sub-species around the Pacific Rim. Young steelhead are brightly coloured with tints of red, green-yellow, orange and gold. Steelhead live up to nine years and spend between one and three years in freshwater before smolting and entering the ocean. Unlike most of the other Pacific salmon, some individuals live to spawn more than once. Fish that have spawned and return to the ocean are termed "kelts". Up to 20 per cent of spawners, mostly females, are repeat spawners, and individuals can spawn many times. Like chinook

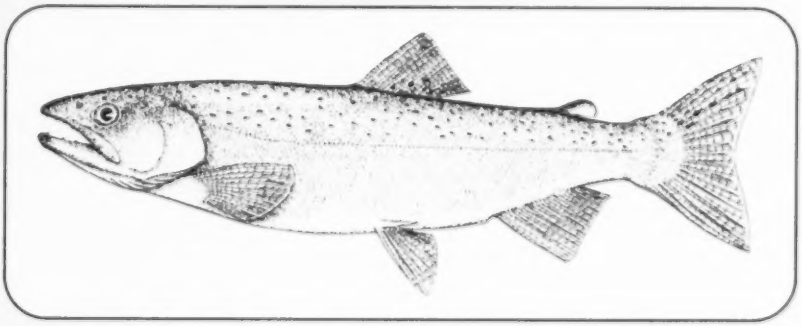

Figure 5. Coho salmon (Oncorhynchus kisutch)

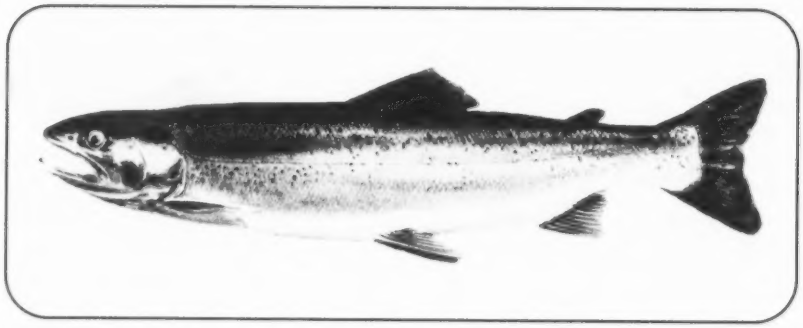

Figure 6. Steelhead salmon (Oncorhynchus mykiss)

and sockeye, there are races of steelhead distinguished by the timing of their spawning migration.

"Winter run" fish enter rivers to spawn from November to May and spawn soon afterward. "Summer run" fish enter freshwater as immature fish between April and October. Spawning occurs from January to May for both races. A population consists of fish of one race or the other, although both races can occur in neighboring rivers. Young steelhead prefer fast flowing water in the mainstream of rivers where there is cool and well oxygenated water. Older juveniles prefer deeper pool habitats with good flow. These habitat preferences make steelhead particularly susceptible to types of habitat disturbance that introduce sediment to fill in pools and removes streamside vegetation that shades the water, keeping it cool. After entering the ocean, steelhead move rapidly offshore and migrate along the coast and out into the Gulf of Alaska. Steelhead are generally not captured in ocean fisheries that exploit species like coho and chinook, which are more oriented to the coast. Summer run steelhead are susceptible to net fisheries for summer run sockeye populations and gill-net fisheries in the Skeena River. Adjustments to fishing gear, locations and time were required to reduce catches of the famed Skeena steelhead. The winter run steelhead of the rivers on eastern Vancouver Island are currently very depressed due to habitat damage from settlement and forest clearing and because of poor survival of smolts after they enter the ocean.

Cutthroat trout *(Oncorhynchus clarki)* used to be in the genus *Salmo* or trout, but scientists have concluded that they are more like the Pacific salmon than trout. In British Columbia, sea-run or coastal cutthroat trout are found in most of the streams and lakes of the coastal region and are in the major rivers like the Skeena and Fraser. Coastal cutthroat are anadromous which means they spawn in freshwater but spend part of their lives in the ocean. However, unlike most anadromous species, they remain in and around the estuaries of their natal streams and seldom venture further than a few kilometres into the ocean. Because of this behaviour coastal cutthroat are not caught in ocean fisheries, but they are a favourite of recreational anglers who catch them with flies and spinning lures just off river mouths. Young coastal cutthroat remain in freshwater for as little as one year but most smolt at two years and some never go to sea. Adults spawn in mid to late winter and spawn for the first time at three or four years of age. Cutthroat, like steelhead, can spawn more than once. The average length of adult coastal cutthroat is about 45 centimetres. Young cutthroat are highly adaptable in freshwater and occupy most habitat types from quickly flowing water to sloughs and ponds. In their first year or two, young cutthroat are very difficult to distinguish from young steelhead.

Lifecycle – From spawning to hatching, migration and growth

Spawning

If you take a walk along a coastal river in British Columbia during the fall or early winter, chances are you will see Pacific salmon.

Salmon lay their eggs in streambed gravel or in spring-fed lake beaches. The female turns on her side, fans her tail back and forth and scoops out a hollow to make a nest or redd in which to lay her eggs. The male then fertilizes the eggs with sperm *(milt)*. Sometimes, a number of

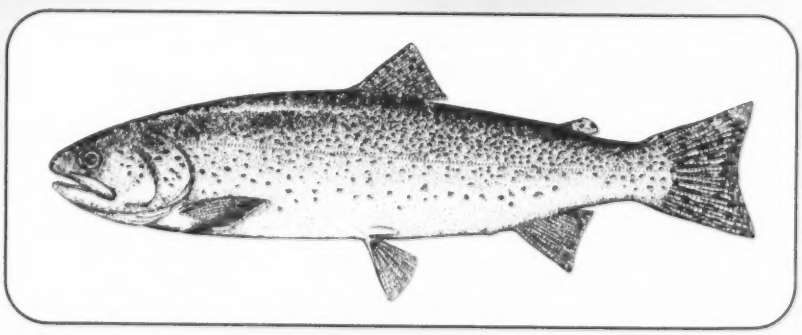

Figure 7. Cutthroat trout (Oncorhynchus clarki)

males join the female at the last minute to fertilize the eggs. At this time, the female covers the nest with gravel. She may build several redds before spawning is complete. It is an exhausting process — all Pacific salmon adults, except steelhead and cutthroat, die shortly after spawning.

Incubation

Salmon eggs develop over the winter, secure within their nest, protected from the cold and all but the most extreme winter storms. In mid or late winter the eggs hatch into tiny fish called *alevins*. Alevins have huge eyes and a sack-like attachment, which contains the remaining egg yolk. Alevins can be quite active in the spaces between the gravel. In streams of the interior or far north where they can freeze down in to the gravel, alevins are known to swim downward to avoid the ice. The yolk supplies them with food until they emerge from the gravel in the spring and begin to feed.

Fry and Smolts

When alevins emerge as fry in the spring, at only 2 centimetres long, they are vulnerable to predators such as herons, ducks and even robins! While pink and chum fry head for the ocean right away, the other species feed and grow in the stream, river or lake for up to three years before heading out to sea. At this stage in their lives, they are called *smolts*, measuring up to 12 centimetres in length. A silvery coating develops on the scales to camouflage smolts from predators. This coating also protects them during the transition from freshwater to saltwater habitats. The smolts of all of the species form large schools as they move into the estuaries and near-shore habitats. This behaviour is known to reduce predation.

Adult Salmon

Sooner or later, all salmon find their way to the ocean or coastal waters. Here they feast on an abundant food supply of plankton, crab larvae, shrimp, squid and small fish which enables the salmon to grow quickly. Depending on the species, they spend between one summer and five years at sea. Finally, they begin the journey back to their native streams. Salmon stop eating just before they enter freshwater. From that point until they die after spawning, with the exception of steelhead and cutthroat, salmon live on stored body fats and protein.

One of the marvels of Pacific salmon is the ability to return to the river where they were hatched. Researchers have shown that some salmon actually return to the exact spot where they were hatched! Researchers have studied this phenomenon for years and understand some of the complexities of salmon navigation. To get back to the river, salmon seem to use some combination of the earth's magnetic field, celestial navigation, patterns of polarized sunlight and instinctive patterns of movement along the continental shelf and other landmarks. Once they get close to their natal river, salmon seem to use unique odours remembered from when they left as smolts. The migration of some species up rivers, through turbulent waters and over seemingly insurmountable waterfalls has inspired numerous stories of perseverance and courage. By the time salmon finally reach their spawning grounds, their bodies are scarred, their fins are ragged and much of their energy is gone. With spawning, a whole new generation of salmon will hatch to migrate, grow and carry out the lifecycle all over again.

Threats to Pacific Salmon

Salmon face both natural and manmade threats. Natural threats include extreme weather that can produce floods that wash away spawning gravels, landslides that can block rivers and even volcanic eruptions that destroy entire rivers. Pacific salmon are superbly adapted to such habitat disturbances and can quickly recolonize damaged areas. In fact, when the glaciers retreated after the last ice age 11,000 years ago, salmon were confined to a few small refuge areas in the eastern Pacific. Since then they have recolonized and adapted to nearly every stream, river and lake that they can swim to.

Salmon face more serious threats from people than from nature. Prior to European contact, First Nations harvested salmon and there was an abundant supply for their needs. In 1852, the Hudson's Bay Company started commercial fishing. By 1870, canned salmon, especially sockeye, was in demand worldwide. Species other than sockeye were often tossed back because canneries did not accept them. The 1900s brought sawmills and logging. Land was cleared throughout much of southern British Columbia often without regard to the effects on rivers and streams. Agriculture, mining and settlement have caused further damage to the habitat that supports salmon. The search for gold in the early 1900s brought placer mining to many areas of interior British Columbia and the Yukon. Placer mining is particularly damaging to salmon because it involves washing and screening large quantities of river gravel, which releases large quantities of sediment that chokes spawning grounds. Intense fisheries developed through the last five decades of the

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To which category does this species belong?

20th Century, and some stocks of salmon declined to low levels. Many of those fisheries harvest fish from many populations, some of which could not support intense harvest. Those populations became severely depressed and some vanished.

Currently, improved fisheries management, habitat protection and stock enhancement programs minimize harmful impacts and reverse past damage, but problems still remain. Changing ocean conditions that may be a product of global warming have led to poor survival in the ocean for some populations of salmon. Expanding human populations demand fishing opportunities on one hand, and land and water for agriculture, forestry and towns on the other. This poses numerous challenges for managing and conserving Pacific salmon.

Management

Fisheries and Oceans Canada manages sockeye, pink, chum, chinook and coho salmon, while the Province of British Columbia is responsible for steelhead and cutthroat. Fisheries and Oceans Canada develops and implements integrated fisheries management plans based on stock assessment advice and consultation with various users of the resource. The department is also responsible for ensuring that all fishing plans meet conservation and Aboriginal fishery obligations. Activities include:

- assessing salmon stock health;
- developing pre-season fishing plans for all fisheries in consultation with fishers and First Nations;
- addressing policy issues related to the development of fishing plans;
- in-season harvest management;
- post-season assessment of management plan delivery;
- developing partnership agreements with industry;
- implementing new fisheries management policies; and
- addressing fisheries management concerns related to the Canada–U.S. Pacific Salmon Treaty.

Economic Value

For the people of Canada's Pacific coast, salmon are far more than just fish — they are part of the culture. First Nations cultures have strong and ancient traditions honouring the return of the first salmon of the year. Salmon continue to form a large and essential food source for Aboriginal people. There are large commercial and recreational fisheries for all species of salmon and a growing aquaculture industry. Today, salmon are consumed fresh, smoked, dried or canned. In an average year about 28 million salmon, 75 per cent of them pink and sockeye, are caught in British Columbia with a landed value of approximately $250 million. The recreational fishery in southern British Columbia has an even larger impact with a value to the economy estimated to be over $500 million.

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